

Space Weather Technical Forecast

Issued on Sunday, 23 April 2023 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Strong geomagnetic storm/G3 from CME forecast Day 2 (Monday 24 April). Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with a handful of minor C-class flares. There are currently five numbered sunspot regions on the visible disc. AR3282 approaching the northwest limb is the largest grouping and has lost a few more intermediate spots in recent hours. AR3285 in the southeast is second largest with little change. The remaining sunspot regions remain small and stable, including a new and currently unnumbered sunspot region in the far southeast. The large full-halo CME (Coronal Mass Ejection) that left the sun on Friday UTC evening at 21/1812UTC from an M1.7 flare and associated filament eruption from near centre-disc is due to arrive at Earth at the start of the UTC day of Monday 24 April. No other Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, was initially at slightly elevated levels and has now declined to slow-ambient. The solar wind density was mostly at below average levels with a rise observed later in the period. The IMF was stable and weak at or below 7nT until around 23/0800UTC when moderate levels were reached. The north-south component (Bz) was mostly in a narrow weak range between +5/-5nT, before becoming occasionally Moderate late in the period and reaching around -8nT. The phi angle was mostly negative (towards the Sun), before a switch to positive (away from the Sun) around 23/0800UTC. The net effect of the above solar wind measures was Quiet to Unsettled (Kp1-3) geomagnetic activity.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, was slightly enhanced throughout, following the M-class flare and filament eruption from 21/1812UTC, although levels remained below the minor storm (S1) threshold. High energy electron flux (greater than 2MeV) as measured at GOES16 was mostly at Normal Background levels. The associated 24-hour electron fluence was well below the Active threshold on a steady trend, with 2.43e6 integrated pfu observed at 23/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Slight Chance of isolated Moderate activity, mainly due to AR3282 but perhaps also from the AR3285 in the southeast quadrant, otherwise activity is most likely to remain Low.

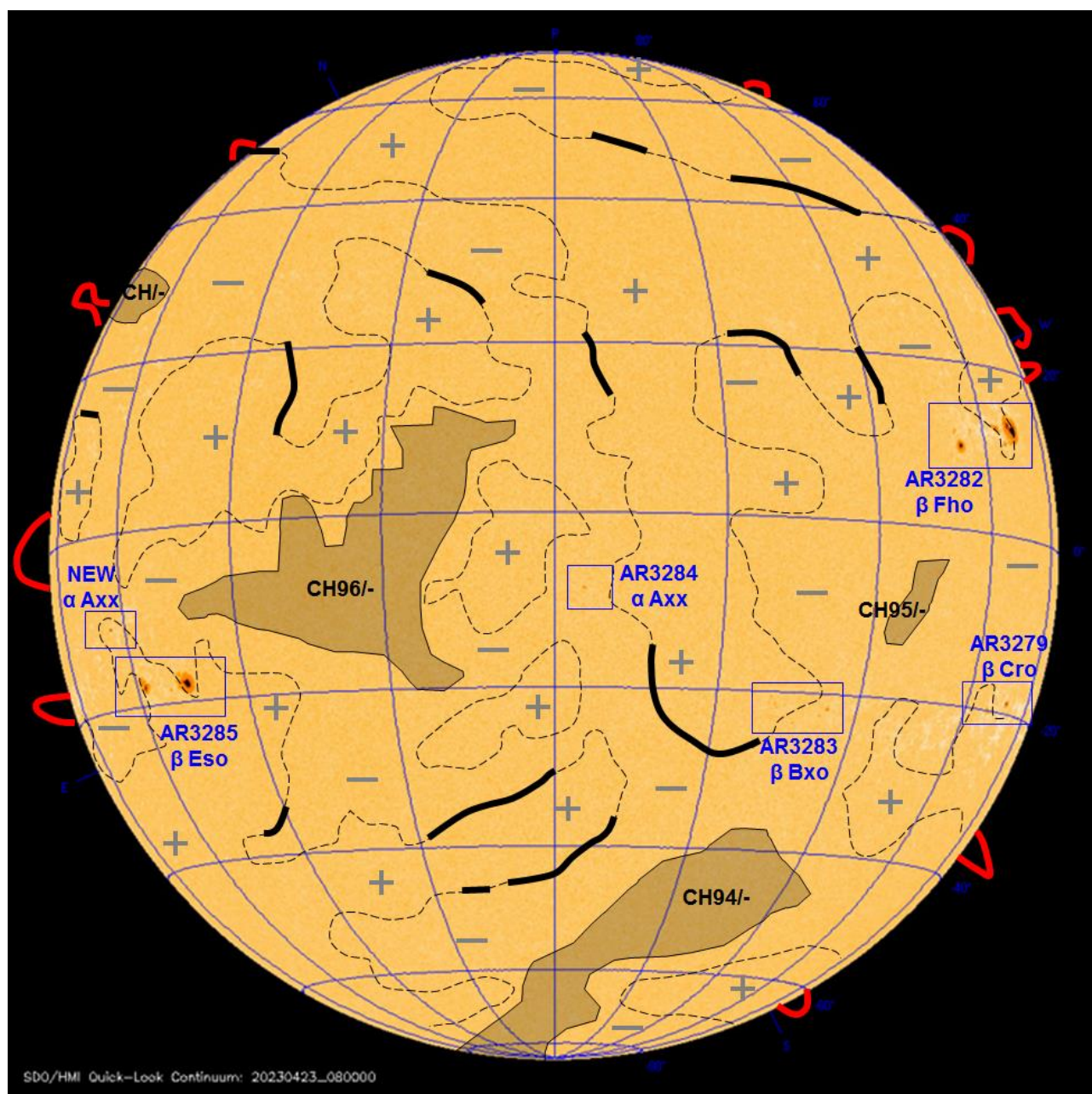
Solar Wind / Geomagnetic Activity: Earth is currently experiencing a slow-ambient solar wind regime at present. There remains a chance of either CH94 or CH95 (both negative) affecting Earth in the next few hours, with solar winds perhaps reaching slightly elevated levels (400-550km/s). The large full-halo CME (Coronal Mass Ejection) that left the sun on Friday evening

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(21/1812 UTC is due to arrive at Earth either late on Day 1 (23 Apr) or in the early hours of Day 2 (24 Apr). The onset of a Minor Geomagnetic Storm (Kp5) is considered Likely during Day 2 (Monday 24 April), with a chance of a Moderate to Strong storm (Kp6 or Kp7). Accompanied with the CME solar winds may reach strong levels with 600-700 km/s or more perhaps being reached. Activity then waning through Day 3 (25 April), and by Day 4 (26 April) geomagnetic activity will probably return to Quiet to Unsettled levels, with solar winds declining towards slightly elevated.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at Background levels, although there is a slight chance of S1 or greater, mainly due to AR3282. High energy (greater than 2MeV) electron flux is currently at Normal Background levels, with little change expected, although a slight increase is possible later in the period in response to HSS effects. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu), but with an increasing trend later in the period- although this may remain suppressed due to on-going CME effects.

Figure 1. Solar Analysis Valid 0800UTC, 23 April 2023.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-γ-δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

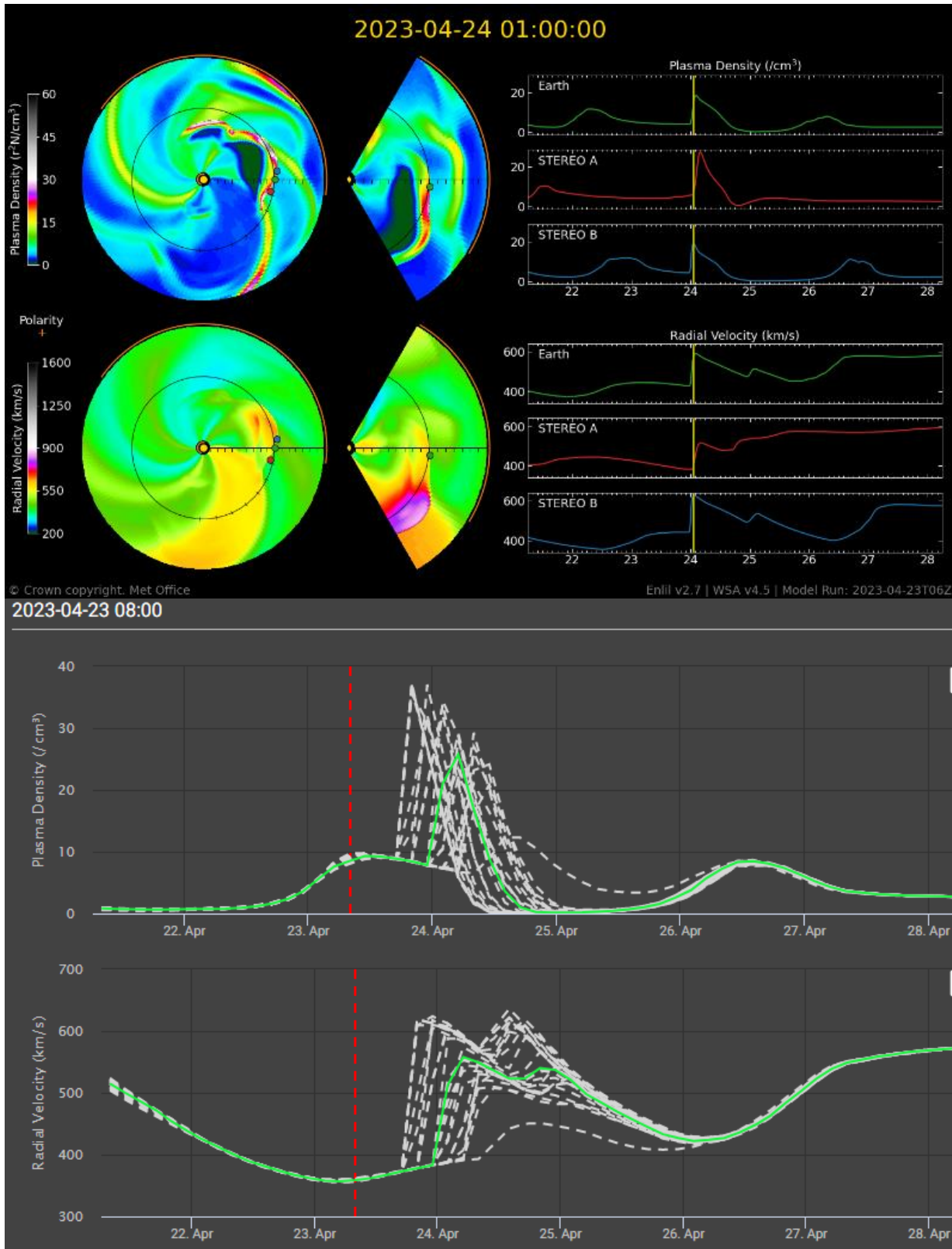
The dominant feature of the four-day forecast is the M1.7 generated CME from centre-disc that left the sun on Friday evening at 21/1812UTC. Available imagery for the event is very good, although the very narrow angular difference between STEREO A and Lasco perspectives obviously introduces error bars into the measurement, as does the fact that the CME ejecta itself is rather complex, with numerous lobes of the shock apparently interacting - especially to the northwest of the Sun-Earth line. The main ejecta from this event has been assumed to be that seen heading narrowly southwest, with the CME's angular width therefore significantly impinging on the Sun-Earth line. Earth is currently at slow-ambient levels. CH94 or CH95 (both negative) may become geoeffective in coming hours and recent observations at L1 give a hint of this with rises in Bt, density and -Bz, along with switch in phi angle. CH94 is a high latitude feature and may pass below Earth, with this feature also smaller and presumably slower than on the previous rotation. CH95 is more centrally located and probably more favoured for connection. Slightly elevated levels may be reached by the start of day 2 (24 April) at around 400-450km/s. The onset of a Minor Geomagnetic Storm (Kp5) is considered Likely during Day 2 (Monday 24 April), with a chance of a Moderate to Strong storm (Kp6 or Kp7). Accompanied with the CME solar winds may reach strong levels with 600-700 km/s or more perhaps being reached. Activity then waning through Day 3 (25 April), and by Day 4 (26 April) geomagnetic activity will probably return to Quiet to Unsettled levels, with solar winds declining towards slightly elevated.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	30	80	40	10
Strong	G3	No	20	50	20	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21/2121	Full Halo	Flare/Filament eruption	Centre-West	1081 km/s	24/0200UTC	Chance (20-50%) of strong geomagnetic storm (G3)

Figure 2: Met Office ENLIL model output including latest supercomputer ensemble run.

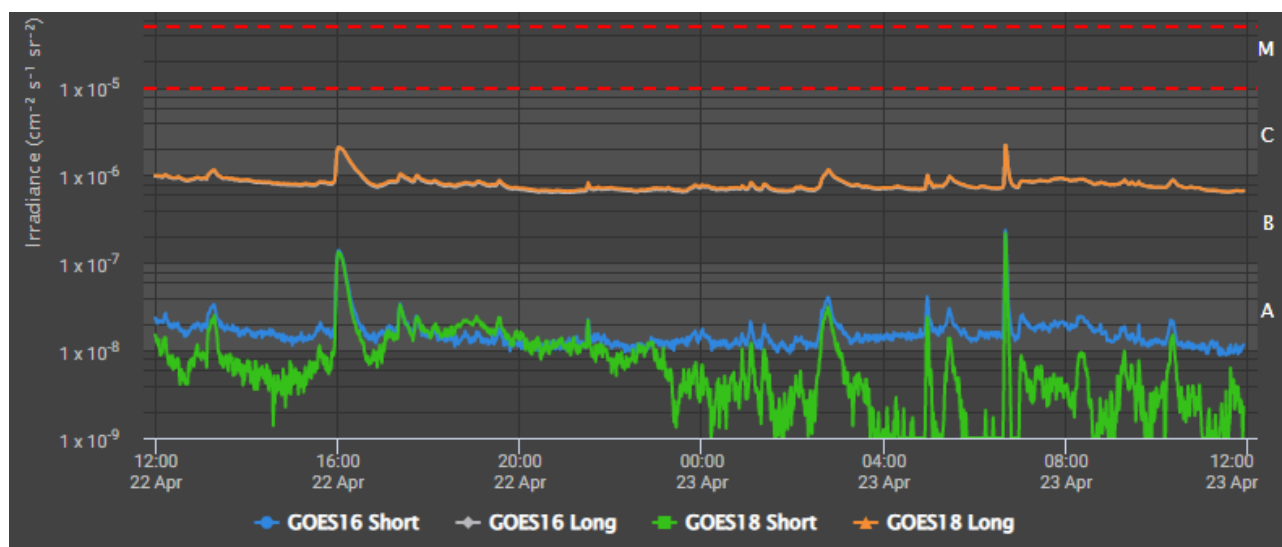


Radio Blackouts - X-Ray Flares:

There are currently five numbered sunspot regions on the visible disc. AR3282 approaching the northwest limb is the largest grouping and has lost a few more intermediate spots in recent hours. AR3285 in the southeast is second largest with little change. The remaining sunspot regions remain small and stable, including a new and currently unnumbered sunspot region in the far southeast. Far side imagery is indicating one or two new active regions could rotate across the eastern limb early in the coming week, with a slight increase in M-class flare probabilities indicated in the table. However this is balanced by the departure on AR3282 by the same time. Over the next couple of days solar activity is likely to remain Low, with a 20% chance of becoming Moderate given any isolated M-class flares. These most likely from AR3282, but perhaps also from AR3285, which comprise the two largest regions on the current disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: Latest X-ray flux plot at GEO with little in the way of significant activity recorded.



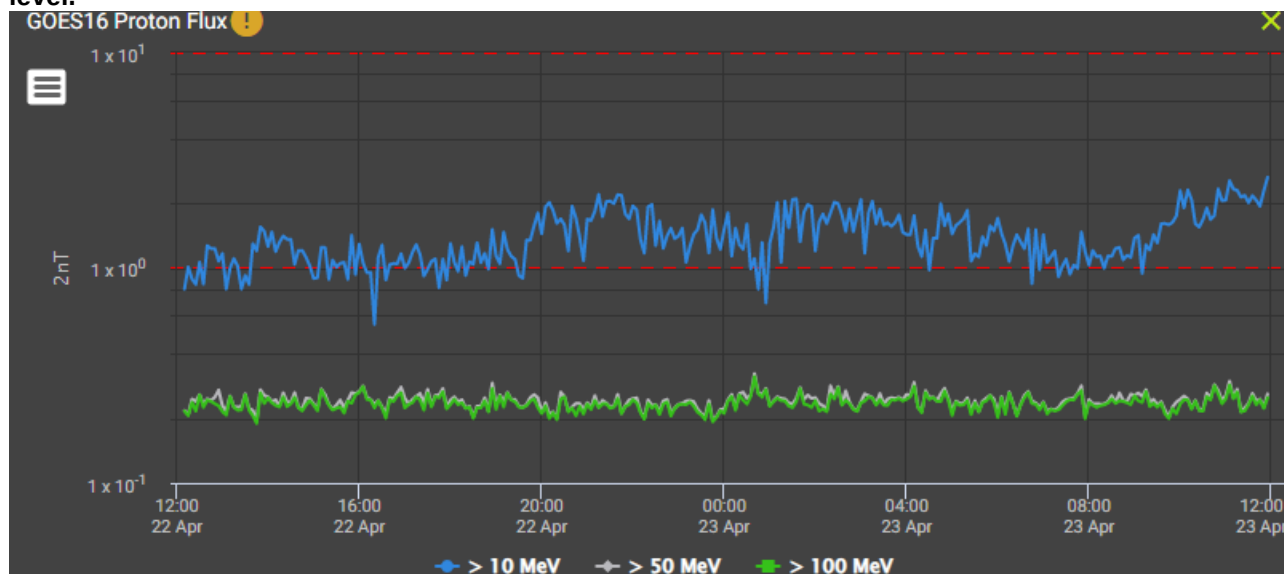
Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16, is currently at Background levels, with a minor response noted in the proton spectrum at GOES16 after the M1.7 flare from near AR3283 on the 21 April. This is reflected by a slight response recorded in lower energies at ACE EPAM LEMS, although there may be other reasons for this (noise or perhaps even the 15 April CME). There is a Chance of reaching S1 or greater, especially should any larger flares occur, with this still thought most likely from AR3282, positioned in a more favourable position, in the northwest quadrant.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	40	20	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

Figure 4: Proton flux at GEO showing slight increase in activity over past 24 hours, but below S1 level.



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy (greater than 2MeV) electron flux is currently at Normal Background levels. The most likely drivers of any change to this state of affairs are the twin negative coronal holes CH94/- and CH95/- A 400-450km/s fast wind may occur, however this would be marginal for electron flux to breach the diurnal High threshold. The chances of 24-hour integrated electron fluence breaching Active are considered Slight during the period, probably reaching a new equilibrium into the new UTC working week, with the caveat that the driving coronal hole fast winds and possibly interrupting CME giving a lowering of confidence.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	20
Very Active	$\geq 2\text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: High energy electron flux (>2MeV) at GEO and Met Office REFM output.

